

IceCube Construction and Ice Quality

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for the IceCube Collaboration

TMEX 18

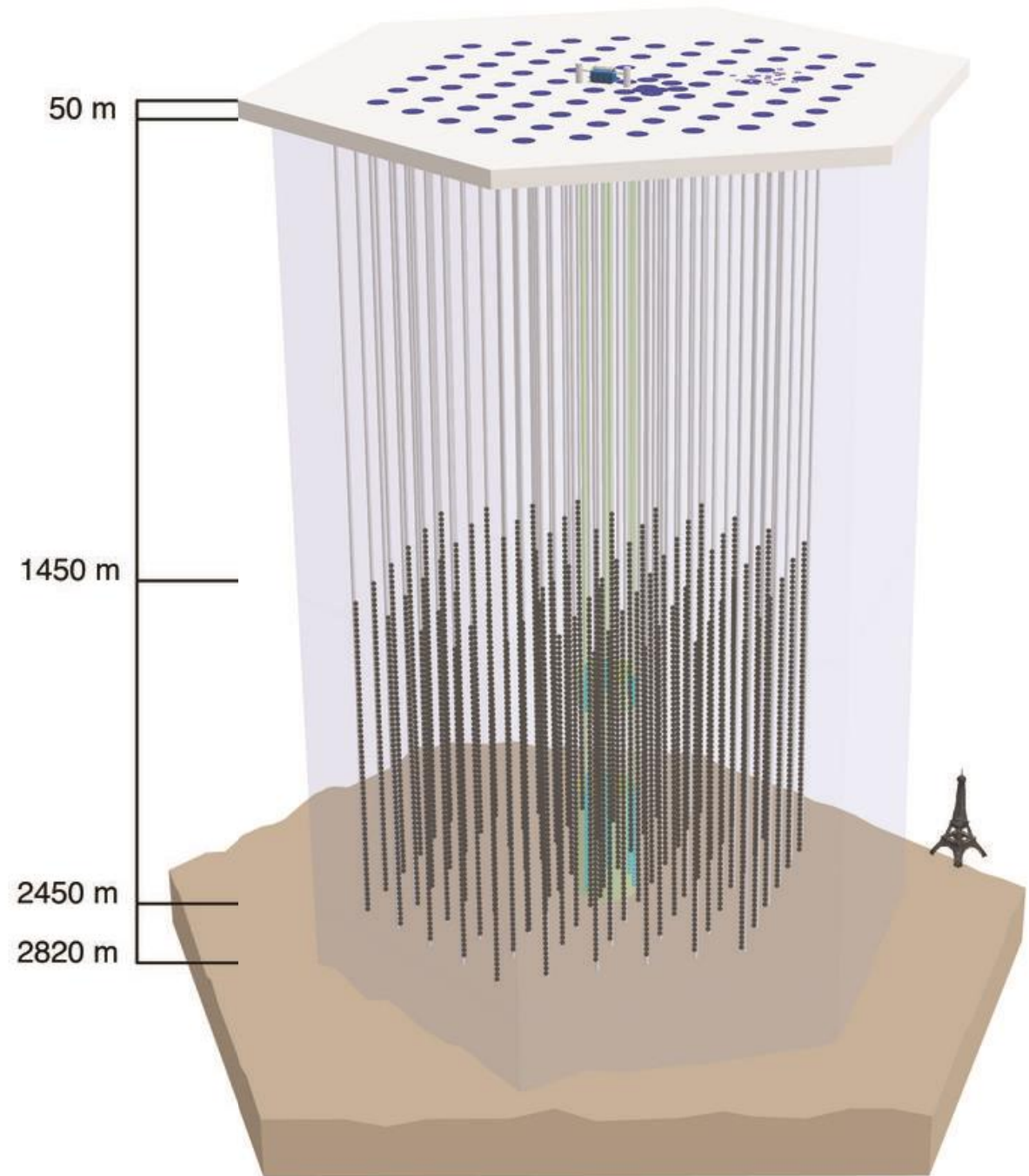
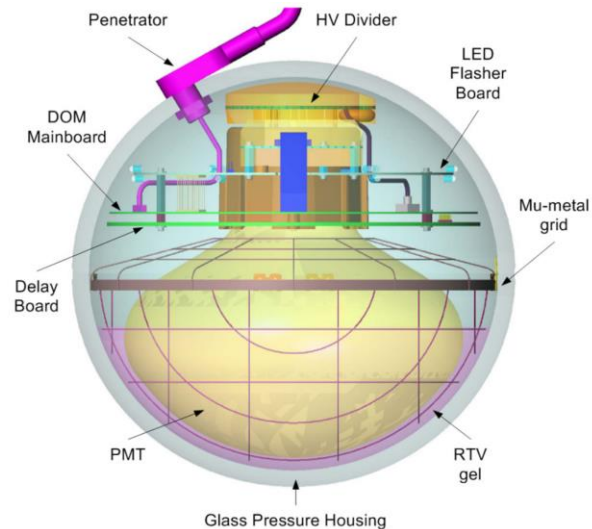
Warsaw, Poland

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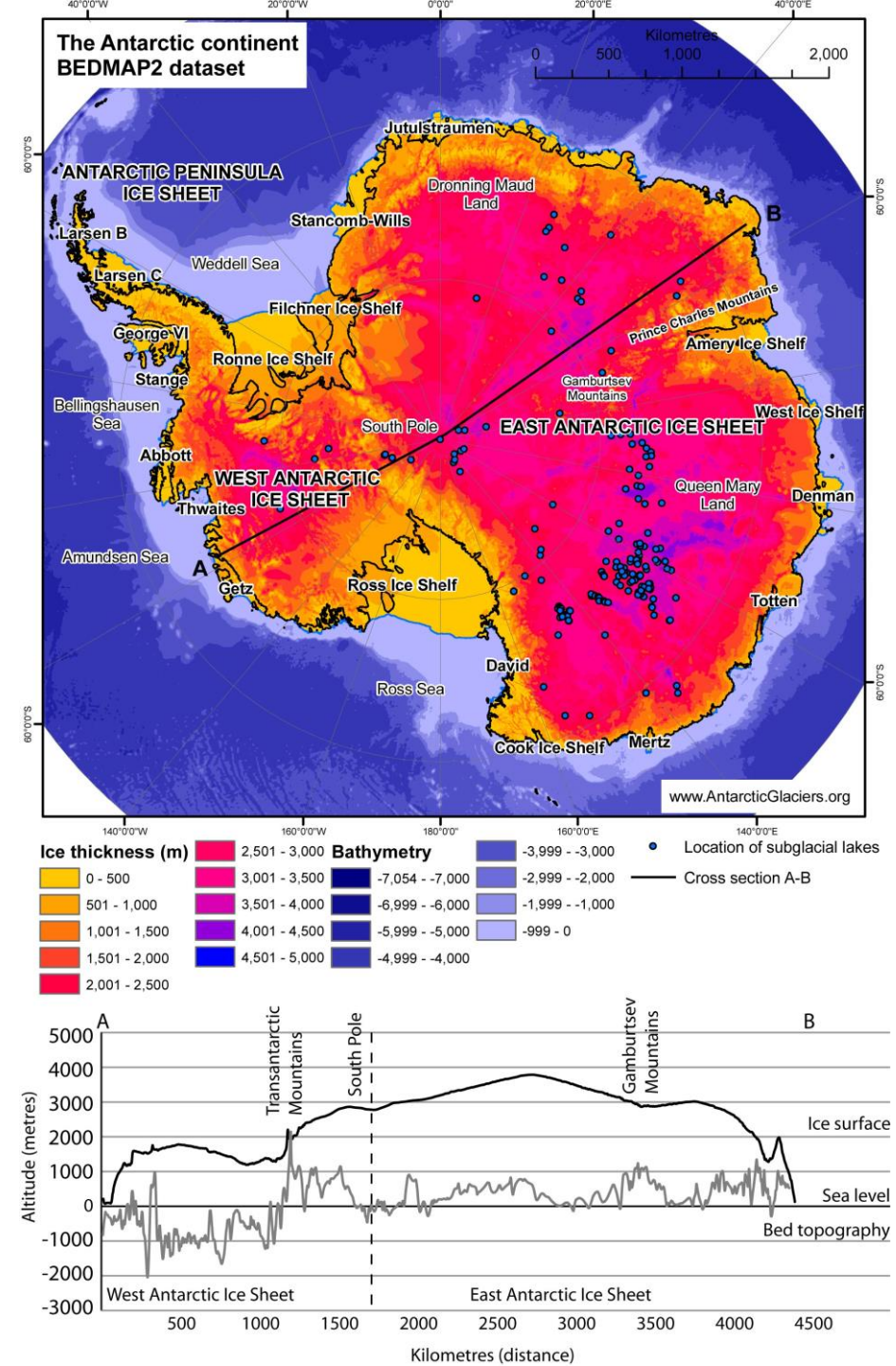
IceCube ν detector

- 1.5 – 2.5 km under ice
- 5,160 DOMs
- 86 strings
- Spacing: 17m in z, 125 in x-y



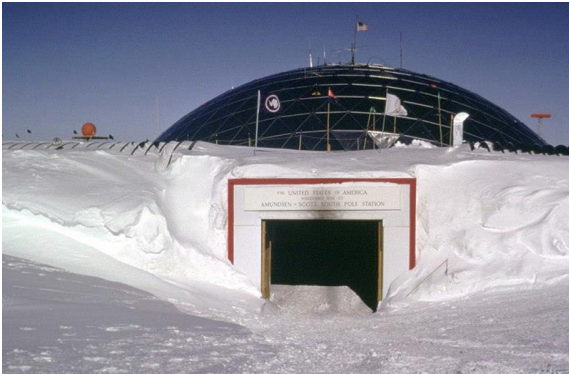
Why the South Pole?

- A lot of deep, clear ice
 - Thick glacier
 - No light pollution
 - Effectively static
- Logistic support
 - All airlifted



Transport and logistics

- Construction work only in summer: December – February
- Passengers and cargo transported in LC-130s
- 2.1 million kilograms of cargo for the project



Deployment - Drilling with hot water

- 5 MW Drill power plant → water @ 90°C in closed loop
- 21,000 liters of jet fuel / hole
- 30 man crew
- 30 h drilling – 3 day cycle time
- Hole lifetime: 24h
- DOM installation: 8h
- Freezeback time: a few weeks



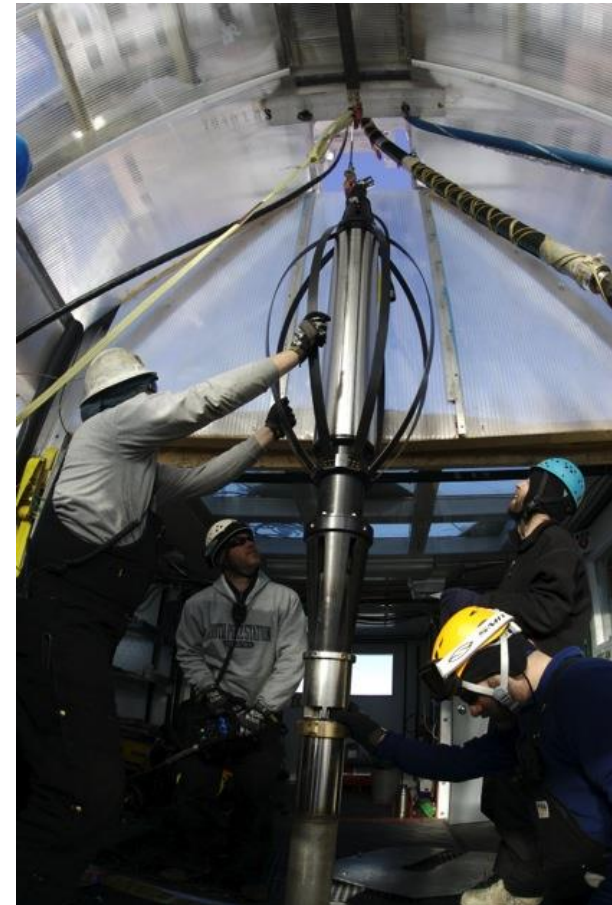
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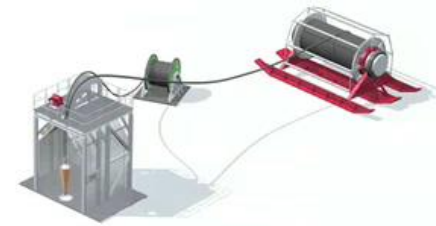


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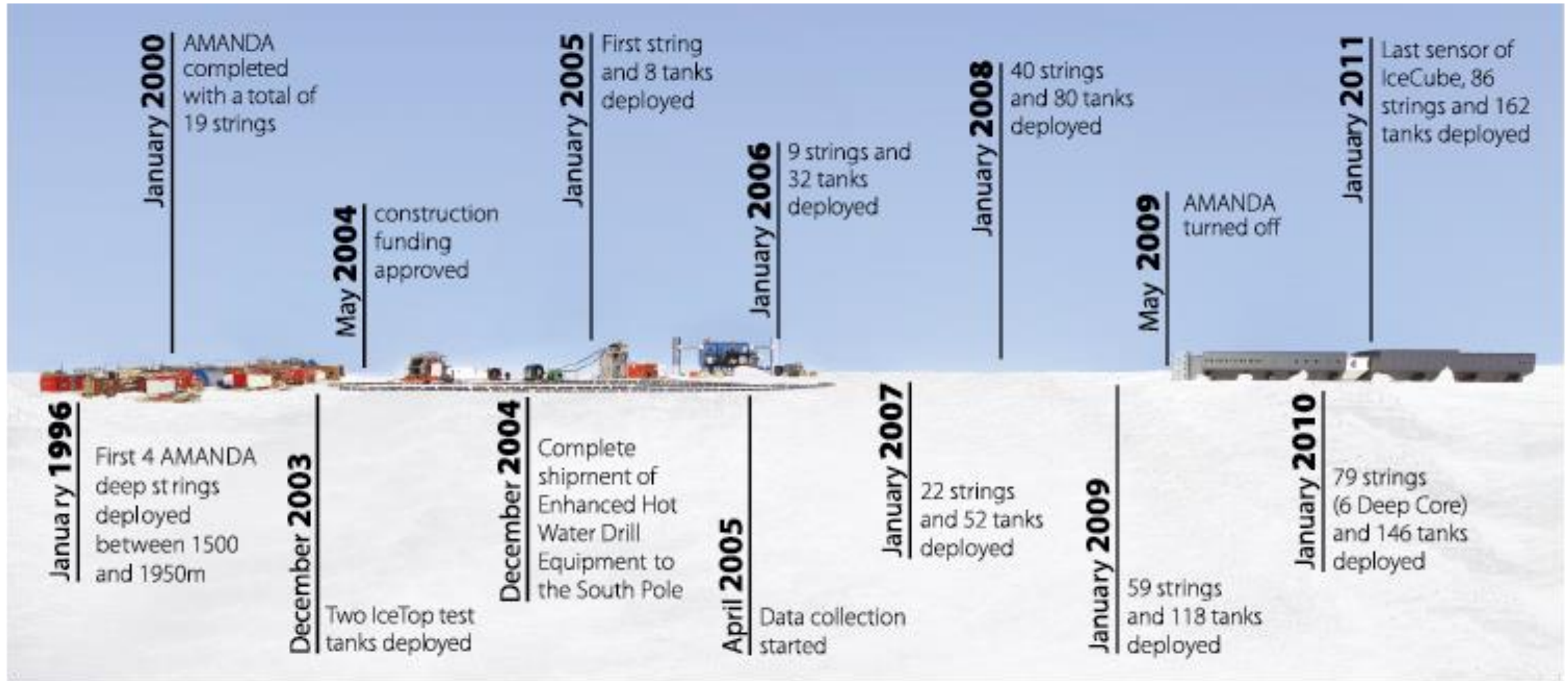
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The IceCube drill



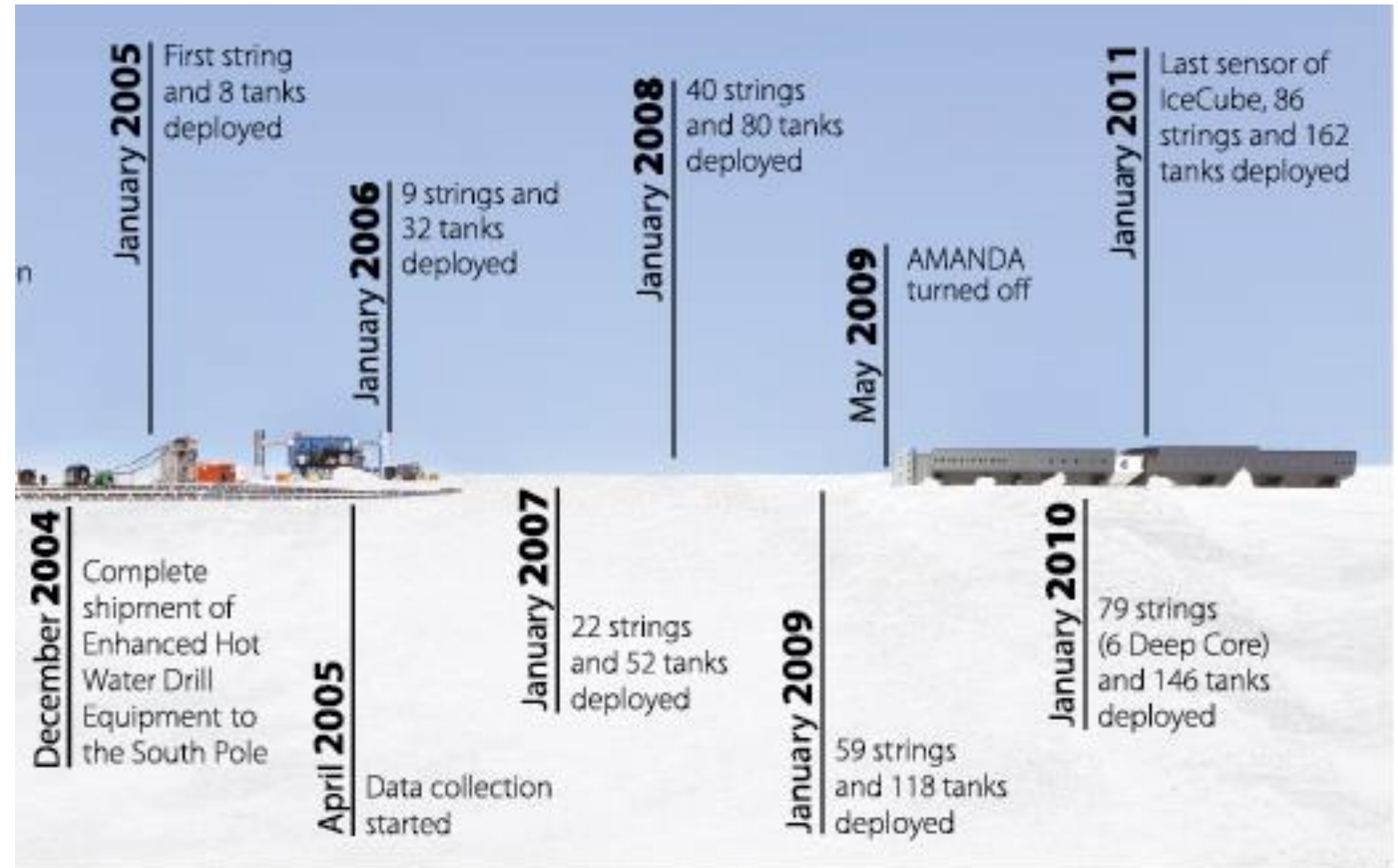
Construction timeline



Construction timeline

First hole took
weeks to drill

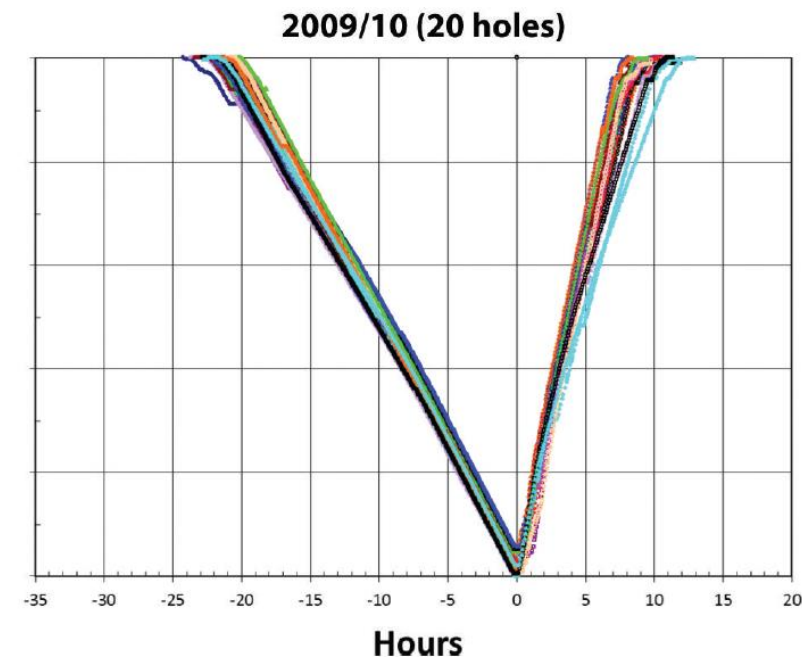
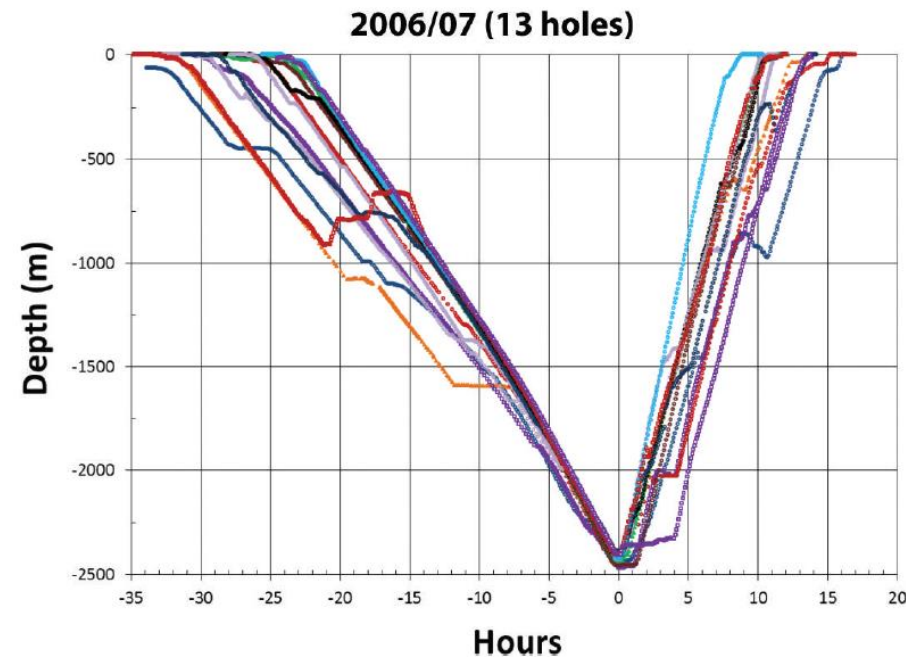
Time went down to
30h/hole by end of
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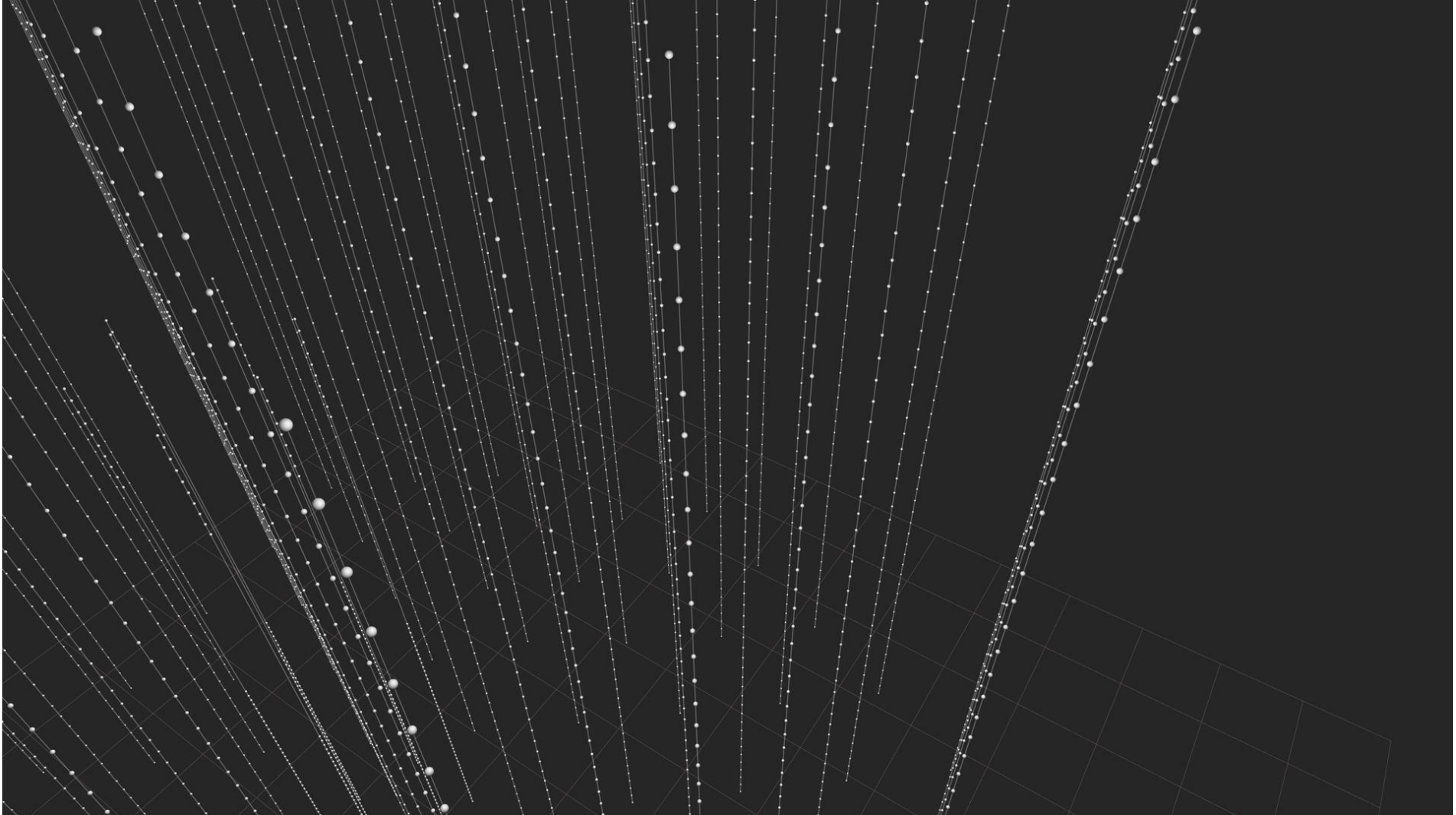


The last DOM deployed



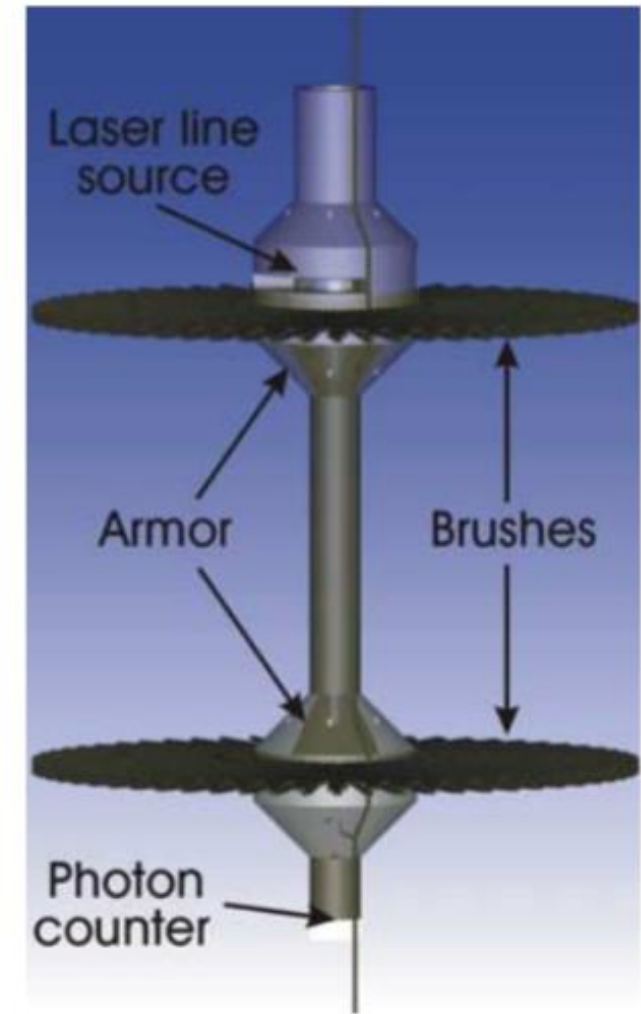
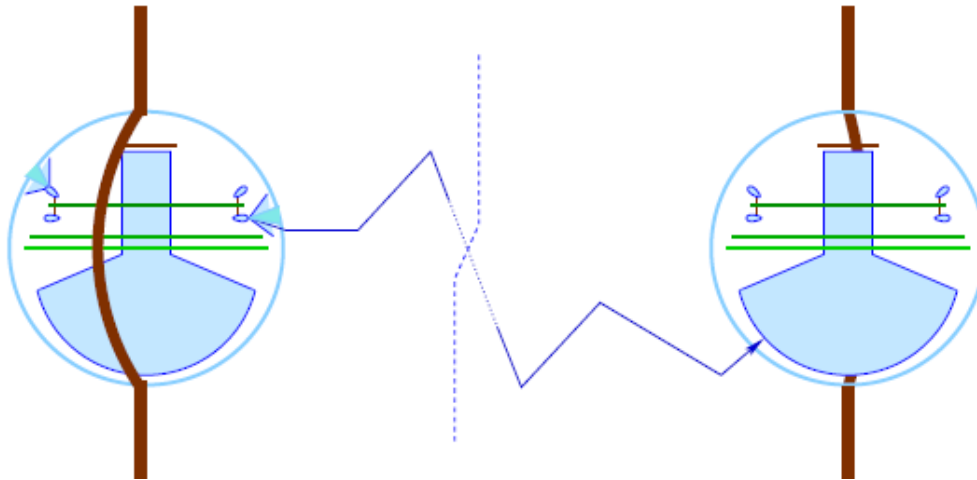


Light in glacial ice



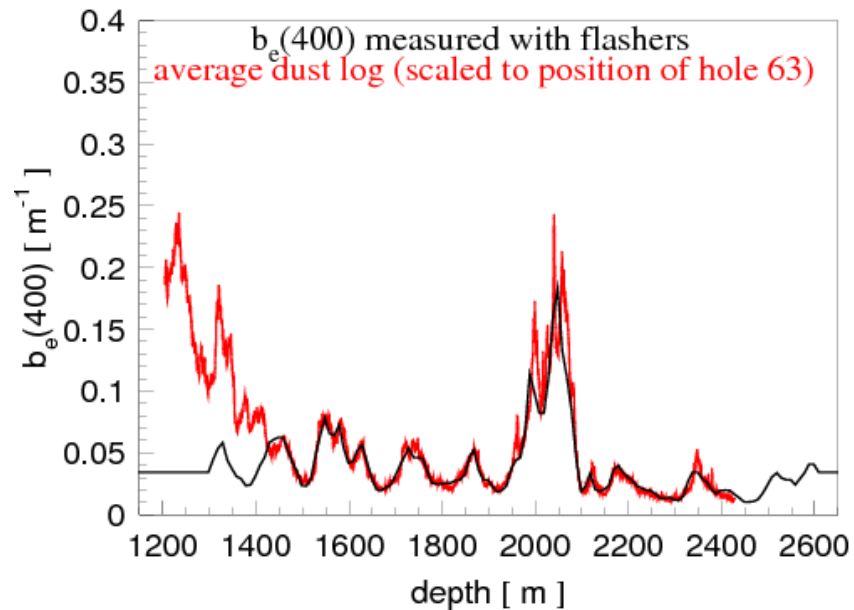
Glacial ice

- Optical scattering & absorption impact physics
- Ice properties mapped by dust logger, ice cores and in-situ LED flashers



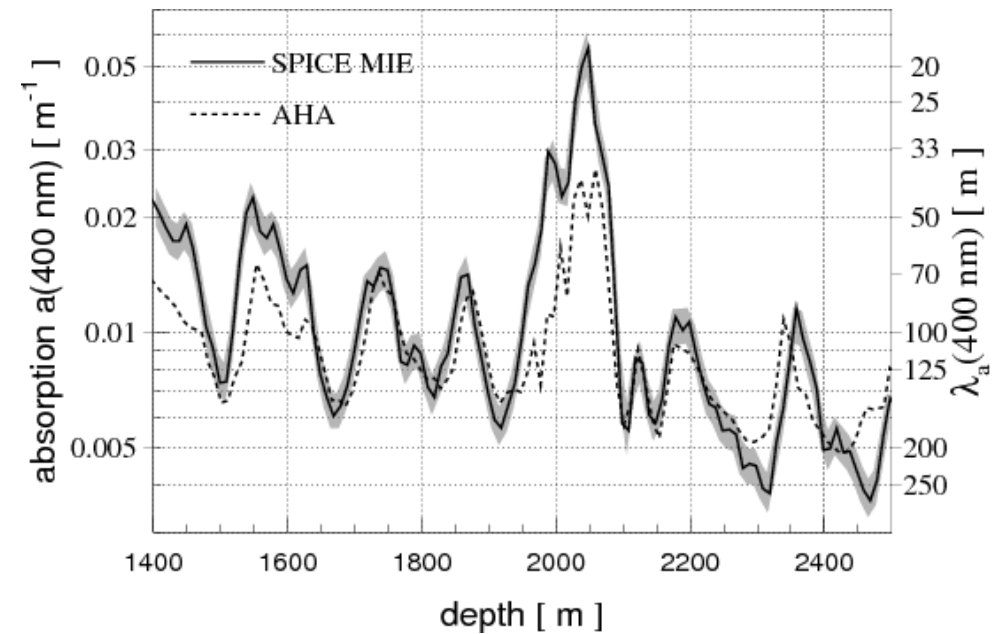
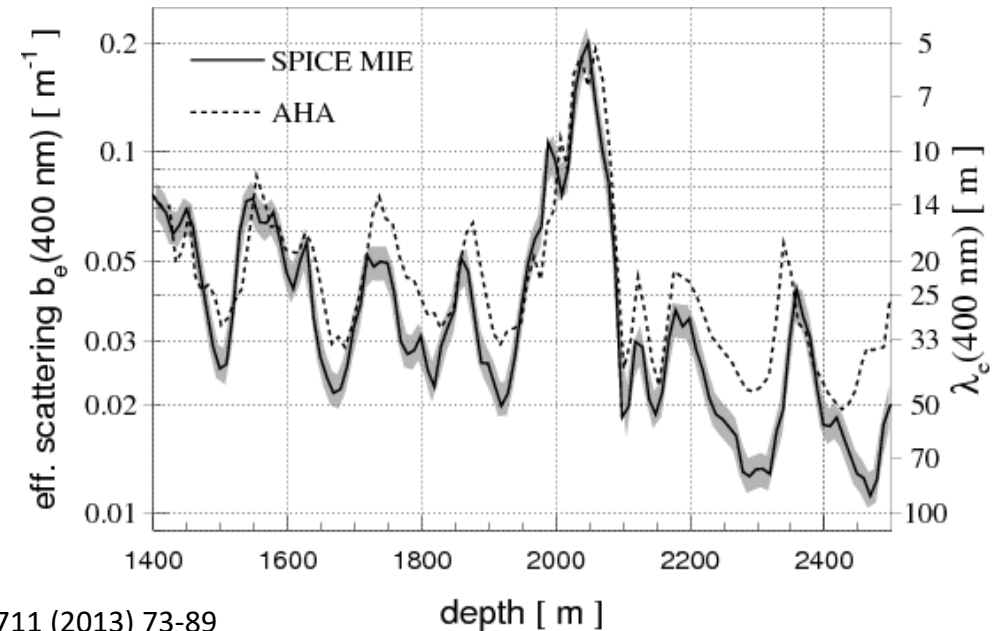
Layered structure

- Good modeling with flashers
- Layered structure visible



Comparison of dust logger and flasher scattering

Nucl.Instrum.Meth. A711 (2013) 73-89



Measured optical properties,

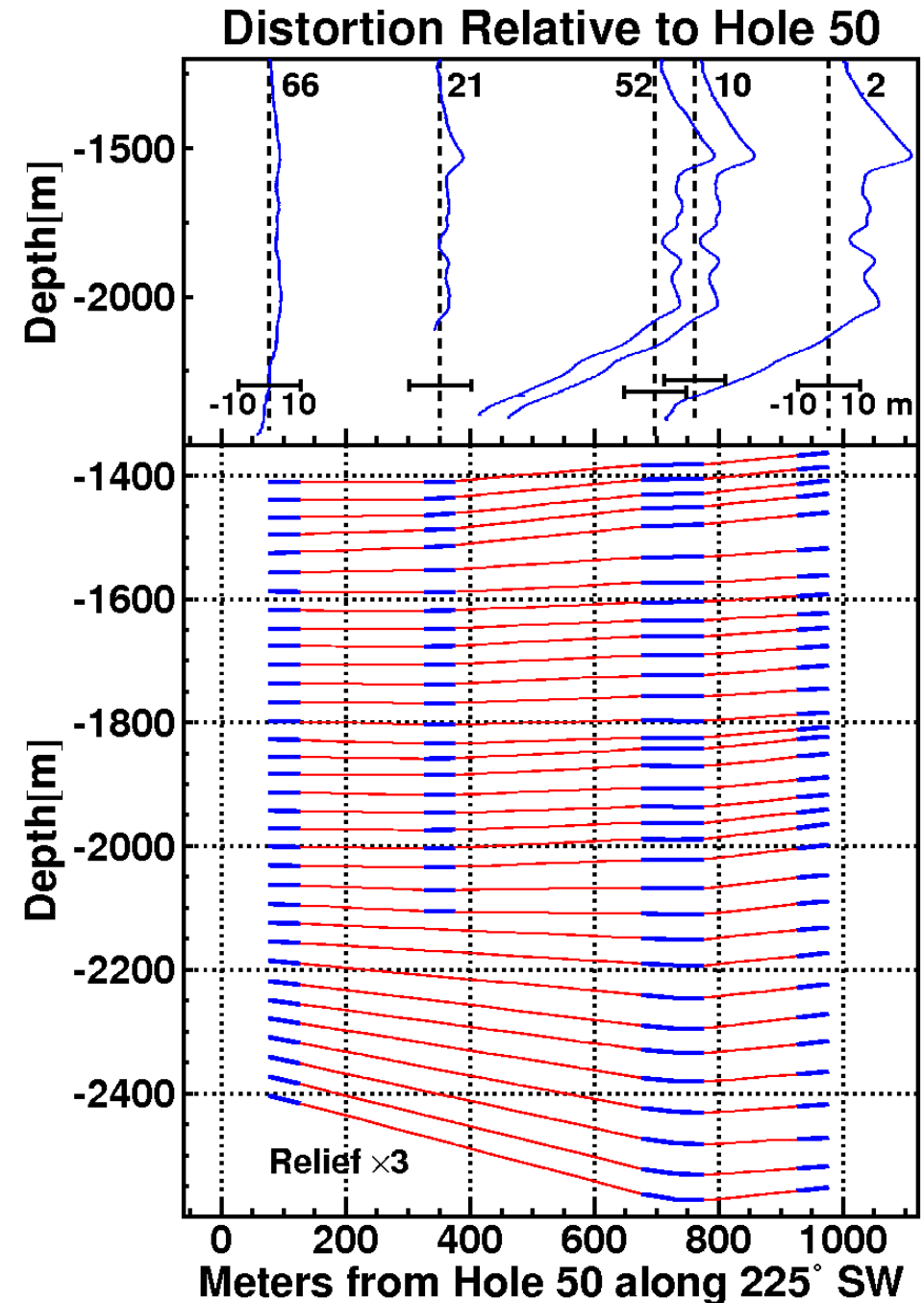
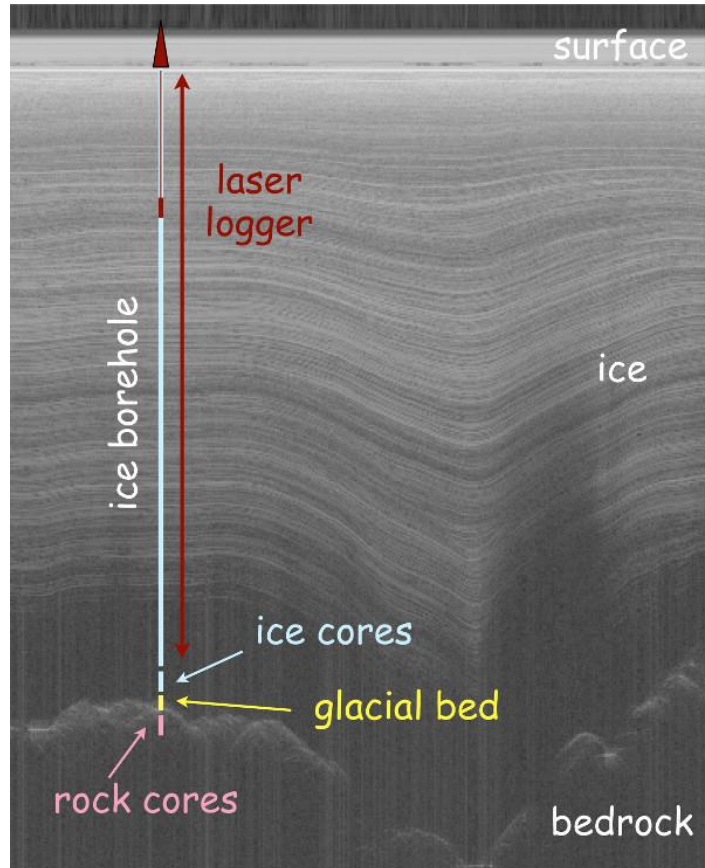
Tilted layers

- The ice surface is flat and smooth, but the bedrock has features



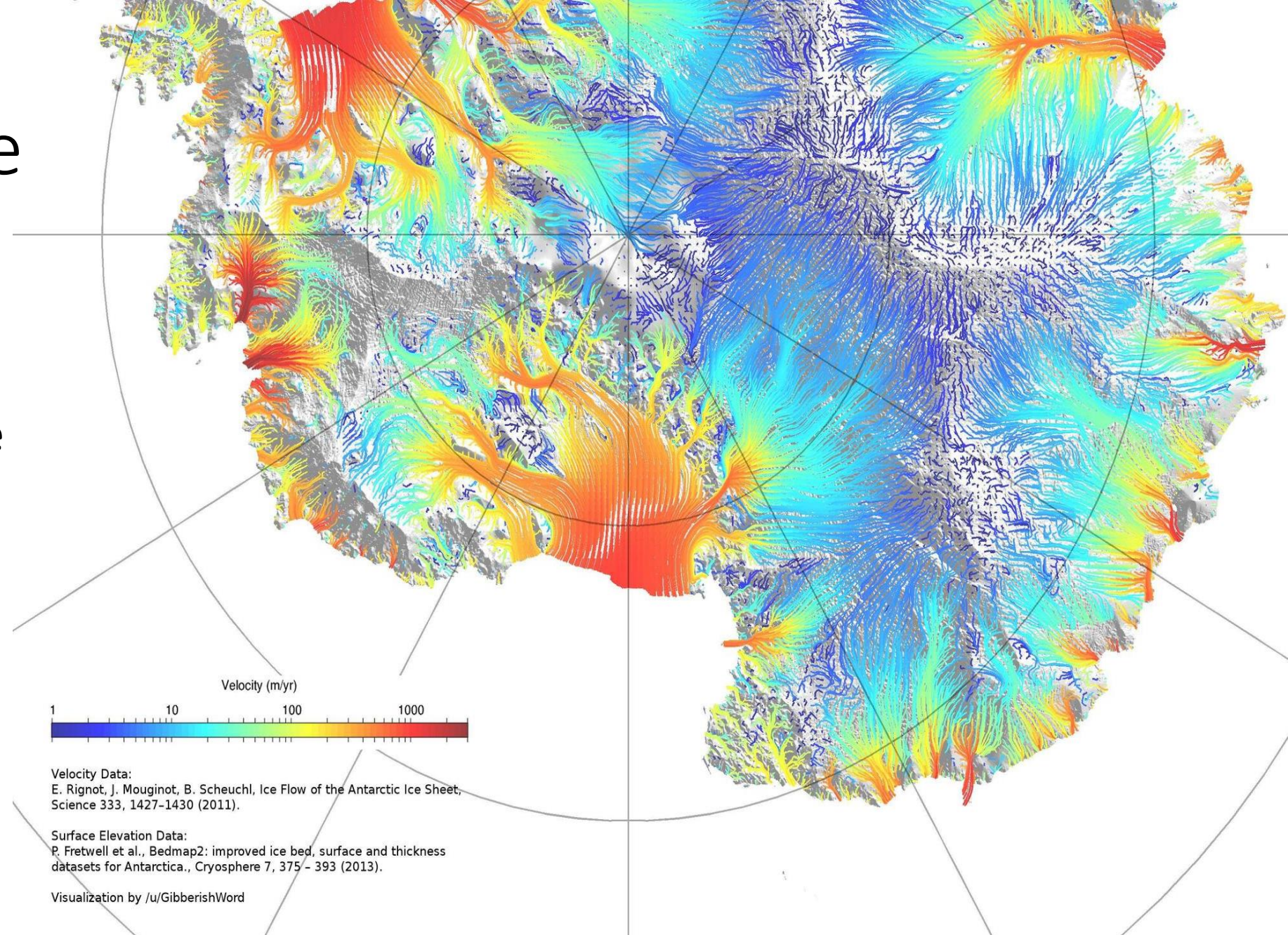
Tilted layers

- Terrain imprints itself on ice



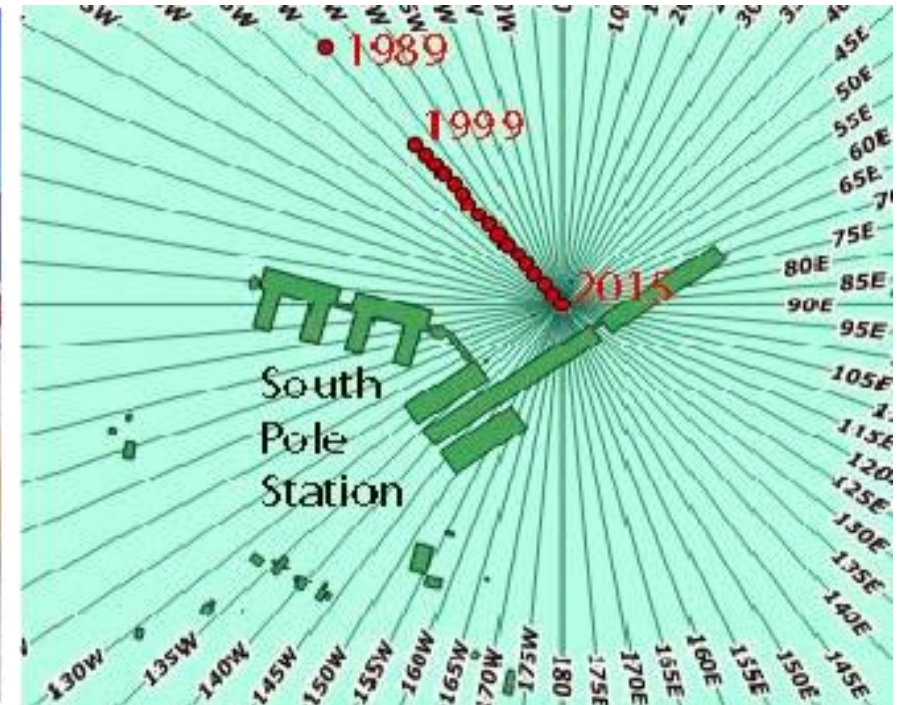
Rivers of ice

- Ice is flowing
- Stresses impact crystal structure and impurities, thus optical properties



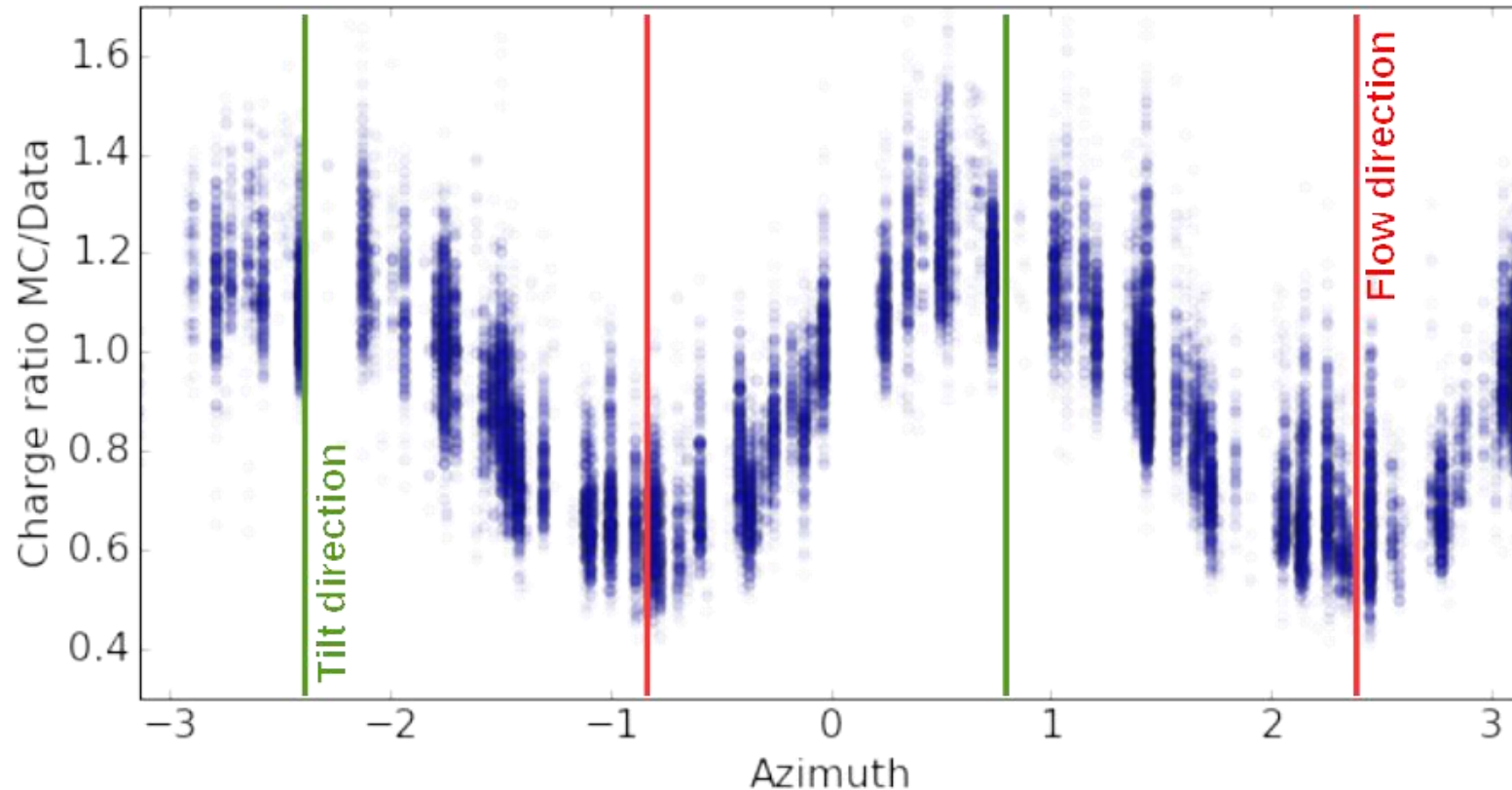
Rivers of ice

- Geographic South Pole marker needs to be moved 10m every season



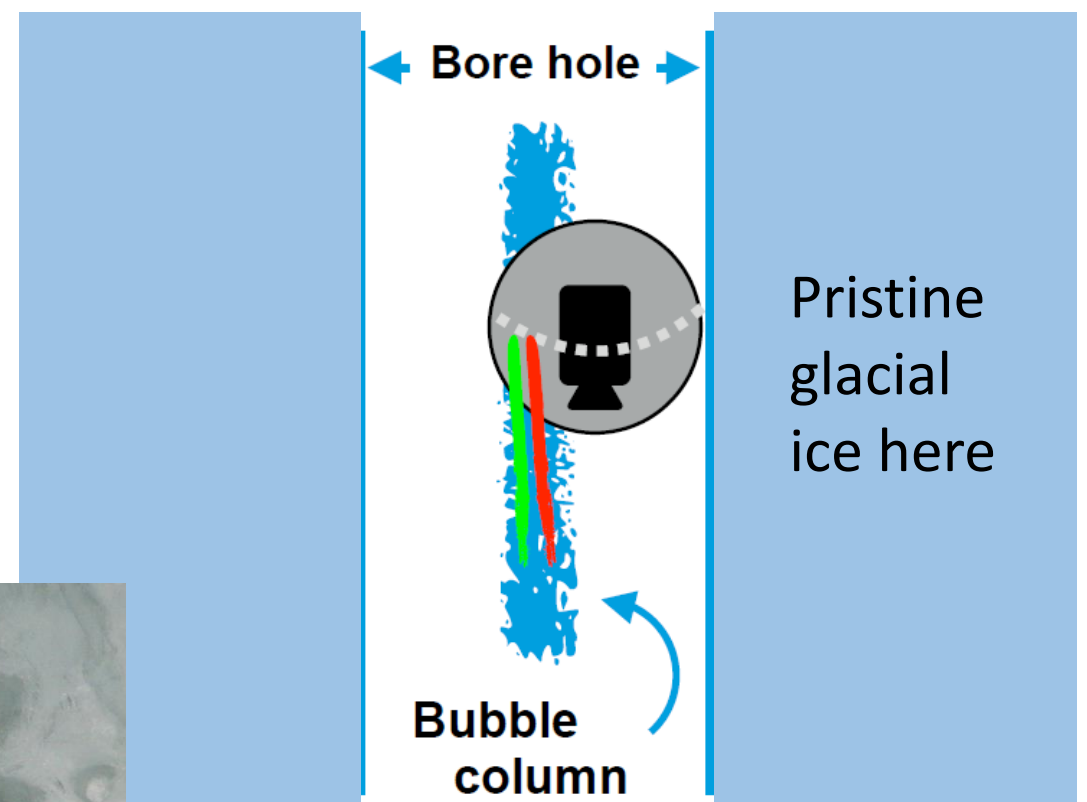
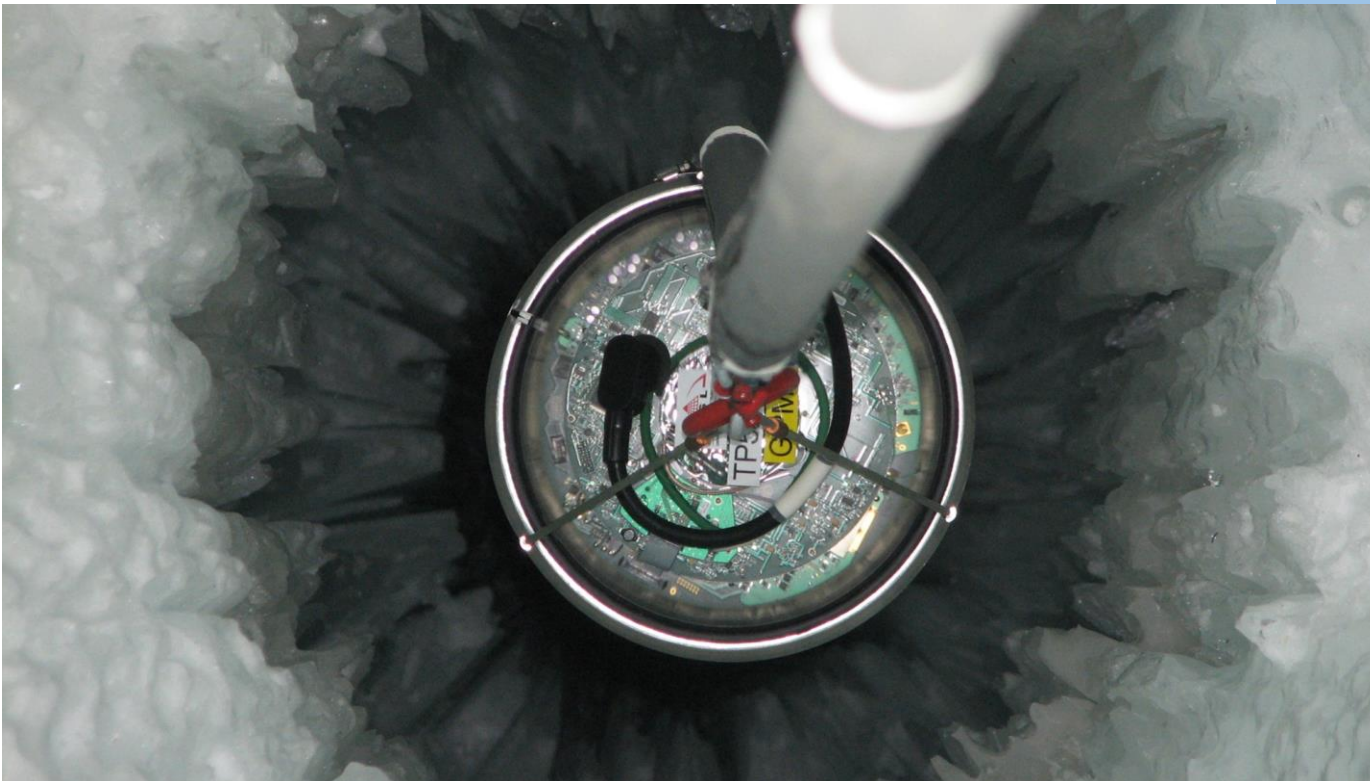
Anisotropy – a result from the flow

- Light attenuation has a direction dependence
 - Less attenuation along flow direction



The ice in the hole

- Drill → Deploy → Wait

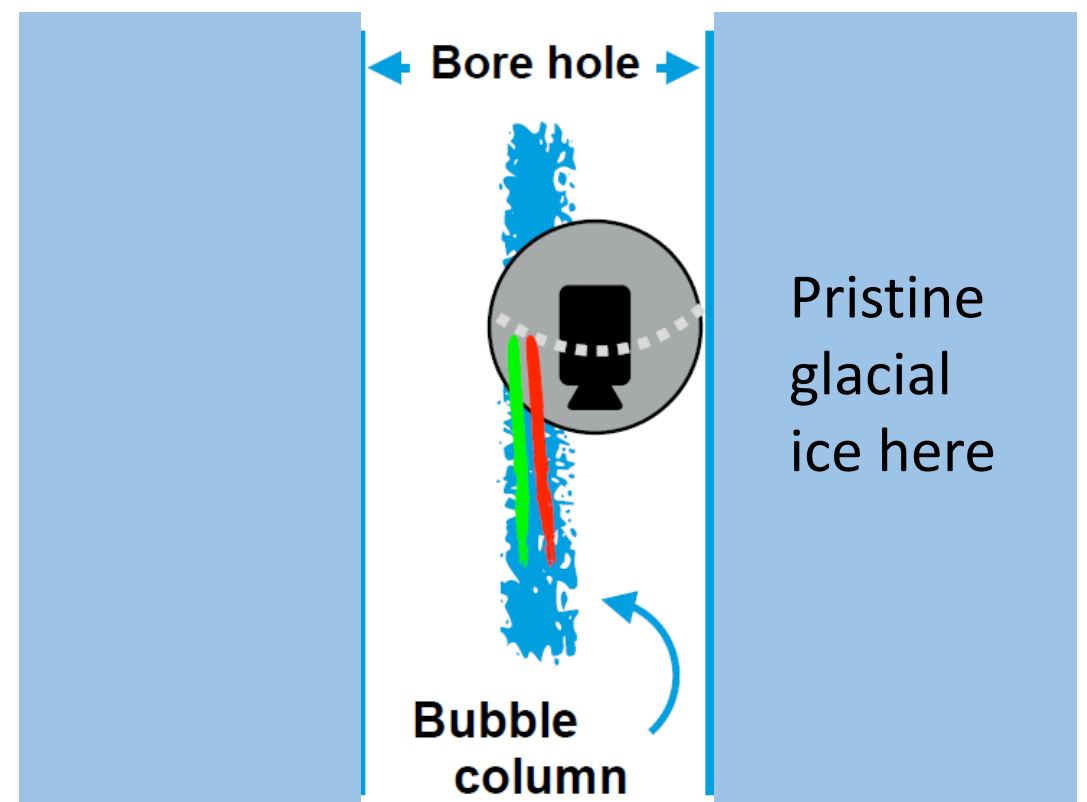


Not so pristine
glacial ice here

Drill could have introduced
impurities and gas (bubbles)

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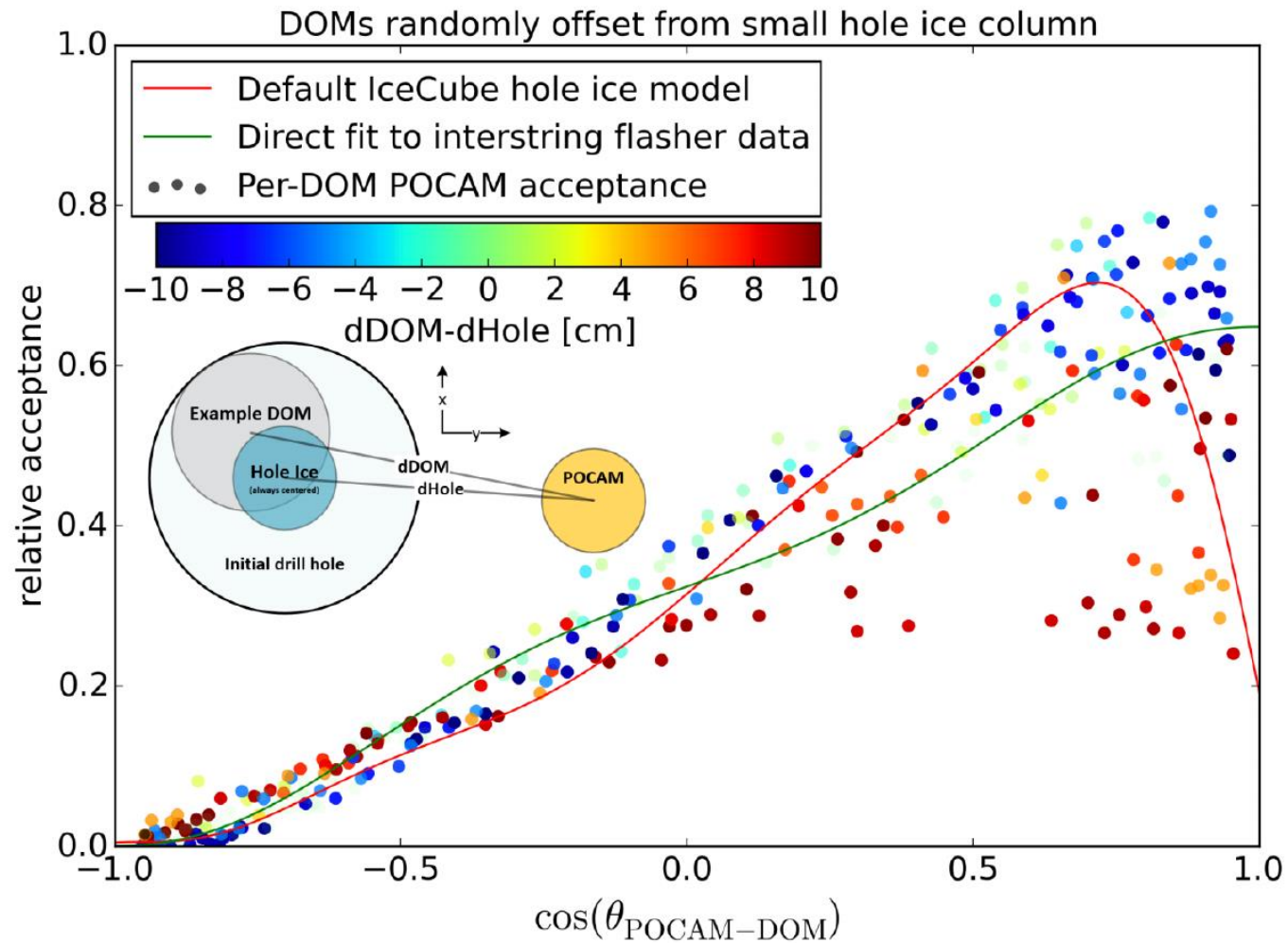
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The POCAM device and hole ice



Calibration sources

Piezo-module^[1]



CCD^[2]



CMOS^[2]



POCAM^[3]



[1] <https://doi.org/10.1051/epjconf/201713506003>

[2] <https://doi.org/10.22323/1.301.1040>

[3] <https://doi.org/10.22323/1.301.0934>

Summary

- Constructing IceCube was an enormous endeavour
 - Remote location, limited construction time, harsh conditions
 - Challenging logistics – still completed in time/budget
 - Gained expertise and developed techniques to do it again
- Ice optical properties being studied thoroughly
 - Tilted layers that flow characterized
 - Still learning about what happened in the holes
 - Upgrade to be loaded with calibration devices to improve knowledge

